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The Impact of Exposure to Previous Disasters on Hospital Disaster Surge Capacity Preparedness in Finland: Hospital disaster surge capacity preparedness

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Original Research

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Abstract

Objective: As disasters are rare and high-impact events, it is important that the learnings from disasters are maximized. The aim of this study was to explore the effect of exposure to a past disaster or mass casualty incident (MCI) on local hospital surge capacity planning.

Methods: The current hospital preparedness plans of hospitals receiving surgical emergency patients in Finland were collected (n = 28) and analyzed using the World Health Organization (WHO) hospital emergency checklist tool. The surge capacity score was compared between the hospitals that had been exposed to a disaster or MCI with those who had not.

Results: The overall median score of all key components on the WHO checklist was 76% (range 24%). The median surge capacity score was 65% (range 39%). There was no statistical difference between the surge capacity score of the hospitals with history of a disaster or MCI compared to those without (65% for both, $P = 0.735$).

Conclusion: Exposure to a past disaster or MCI did not appear to be associated with an increased local hospital disaster surge capacity score. The study suggests that disaster planning should include structured post-action processes for enabling meaningful improvement after an experienced disaster or MCI.

Background

A well designed disaster plan is important for surviving a chaotic and usually unexpected situation with success, and the hospital preparedness plans (HPP) are an essential part of these plans.[1,2] These HPPs must be heavily individualized to a specific site. No HPP is suitable for all sites. Likewise, HPP should remain fluid and iterative documents, with changes being made in response to learnings from exercises or disaster responses.[2] While disaster response literature has emphasized the importance of after-action debriefing for both exercises and responses, there is little evidence to suggest that these debriefings consistently lead to meaningful changes in preparedness for the next disaster.

Surge capacity is a crucial point of a HPP since the awareness of limited surge capacity leads to a realization of the vulnerable aspects in the disaster plan, and emphasizes the need for more regional or national collaboration between hospitals during a disaster.[3] Previous studies have explored the overall national HPPs with selected hospitals, and the surge capacity preparedness, but with no comparison to previous experiences with disasters.[4–10]

Finland has a population of 5.5 million inhabitants. At the time of the study period, the national organization of specialized medical treatment was divided into 21 hospital districts, where each had at least one university or central hospital receiving surgical emergency patients. Finland is not a geologically disaster-prone country and acts of mass violence are rare. As natural disasters are absent and anthropogenic disasters and mass casualty incidents (MCI) are uncommon, the experience of such situations is scarce.

The primary aim of this study was to determine if a past disaster or MCI is associated with a change in a local hospital's surge capacity preparedness. The null hypothesis of no difference in surge capacity preparedness between hospitals with exposure to previous disasters and those with no exposure was tested against the two-sided alternative hypothesis of significant difference. The secondary aim was to tabulate the overall national hospital preparedness in the country.

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HD	Habitants	Hospitals*
HUS	1 685 983	9
P	537 226	1
VS	482 169	1
PP	410 112	1
KS	252 716	1
PS	244 236	1
S	216 752	1
PH	210 057	1
EP	193 207	1
KH	170 925	1
V	169 495	1
PK	164 465	1
KYM	164 456	2
EK	127 757	1
L	116 866	1
ES	98 823	1
KP	77 304	1
K	72 306	1
LP	60 295	1
IS	40 258	1

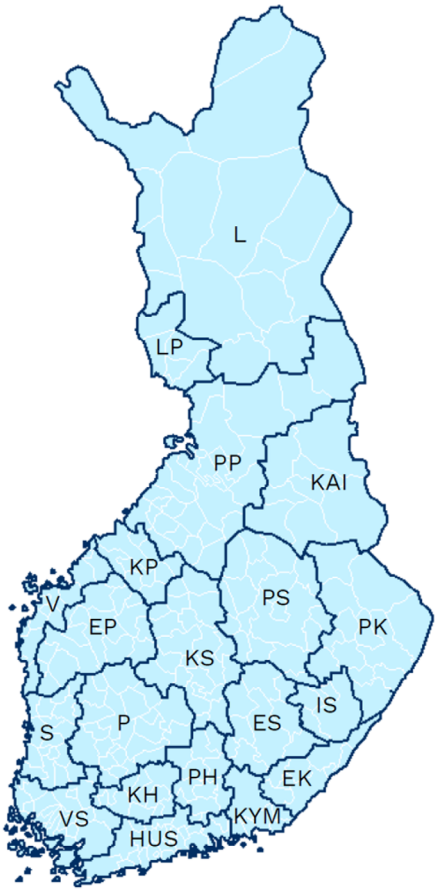

Figure 1. Hospital districts in Finland. Total number of inhabitants in mainland Finland is 5 495 408 (December 31, 2019); the autonomous region of Åland Islands (with 29 884 inhabitants) was not included in the study. *All hospitals included in the study were university and central hospitals receiving surgical emergency patients. University hospital districts are *in italics*. **HD, Hospital District. ***Reference and map with permission of Association of Finnish Municipalities.

Methods

Ethics

This study was approved by the Institutional Review Board (IRB) of the Hospital District of Helsinki and Uusimaa (protocol number HUS/917/2021). All HPPs were handled confidentially, and in accordance with the World Health Organization (WHO) recommendations, the participating hospitals' names and locations were treated as confidential information when reporting the data. The HPPs were obtained with the consent of each hospital district's medical directors knowing the purpose of this study.

Study Design and Participants

Current HPPs of University and central hospitals receiving surgical emergency patients were collected directly from each hospital district's medical directors by a request through e-mail or phone. Twenty hospital districts were included (Figure 1). The HPP of the Åland Islands, which is an autonomous region of Finland, was excluded for its unique regional status. Hospitals that do not receive surgical emergency patients under normal circumstances were excluded from the study. The data collection started in June 2019, and for those who did not respond, a second request was made later that year. Nineteen hospital districts answered the request. Only one hospital district did not respond to multiple requests. Altogether 28 medical contingency plans from 19 hospital districts were collected; one district had nine hospitals, one had two, and 17 districts had one hospital each, which fulfilled the inclusion criteria. The disasters and MCIs in Finland during the past 25 years (January 1, 1994 – December 31, 2018) were collected from official archives.[11]

Evaluation Tool

The medical contingency plans were read and analyzed by the principal investigator (AK) using the all-hazards WHO hospital emergency checklist tool.[12] The checklist was designed for hospital administrators and emergency managers and contains 9 key components: command and control, communication, safety and security, triage, and surge capacity, as well as continuity of essential services, human resources, logistics & supply management, and post-disaster recovery. Each of these key components are further

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divided into 7 to 15 subcomponents or recommended actions, with 3 levels of progress. In this study, 8 key components comprising 67 action items were selected and evaluated. The key component of logistics and supply management was excluded since in Finland, it is part of different preparedness plans and regulated by law.[13] Some items of other key components were excluded from all analyses due to the inability to analyze them based only on the written HPPs (Appendix 1: Supplementary Table). Three levels of progress were determined in the checklist: pending review, in progress, and completed.[12] The items were scored in each HPP based on these 3 levels of progress; 0 points if the item was not mentioned in the HPP at all, 1 point if it was considered at some level, and 2 points if the item was interpreted to be thoroughly discussed in the HPP. The maximum score was 134 and the minimum, 0. The key component of surge capacity in the WHO checklist is divided into 13 actions, including calculating the maximal capacity required for patient admission and care, designating care areas for patient overflow and cancelling nonessential services.[12] For surge capacity, all 13 subjects were included, and the maximum score was 26. Results of the evaluation were classified by the method used by Aldahari *et al.*, and Ingrassia *et al.*, with scores greater than 70% considered to be effective, scores of 35% to 70% classified as insufficient, and scores less than 35% being labelled as unacceptable.[5,10]

Statistical Analysis

All data is presented as median (range, minimum, and maximum) or numbers (%), unless stated otherwise. The scores of key components were compared by the percentage of the maximum score. Pairwise comparisons of continuous variables were performed using the Mann-Whitney *U* test. A *P* value of less than 0.05 was considered statistically significant and all statistical analyses were performed using SPSS software version 27.0 (IBM Corp., Armonk, NY, USA).

Table 1. Disasters and mass casualty incidents in Finland during the past 25 years (January 1, 1994 – December 31, 2018)

Date	Event type	Event specific	Injured	Deceased
April 21, 1996	Traffic accident†	Train derailed	75	4
March 6, 1998	Traffic accident†	Train derailed	94	10
July 6, 2000	Traffic accident*	Train vs. combination vehicle	10	1
October 11, 2002	Violence†	Bombing	164	7
March 19, 2004	Traffic accident*	Bus vs. full-trailer truck	14	23
April 24, 2006	Explosion*	Building site explosion	10	0
November 7, 2007	Violence*	Mass shooting in school	12	9
September 23, 2008	Violence*	Mass shooting in school	3	11
May 26, 2012	Violence*	Mass shooting	7	2
August 18, 2017	Terrorism*	Mass stabbing	8	2
October 26, 2017	Traffic accident*	Train vs. military lorry	11	4
August 24, 2018	Traffic accident*	Bus drove off a bridge	17	4
		Total	**425**	**77**

*MCI, Mass Casualty Incident.
†Disaster.
MCI is defined as an event where a significant demand on the area's medical resources and personnel takes place without overwhelming response capabilities, while in a disaster it does overburden the system.[20] Terrorism can be identified as an act of mass violence with a political, religious, ideological, or social motivation, and intent to reach a larger audience without monetary gain with the manifestation of an enemy.[34]

Results

Table 1 shows the 12 disasters and MCIs in Finland during the past 25 years. There have been three anthropogenic disasters and nine anthropogenic MCIs: six traffic accidents, five acts of violence or terrorism, and one building site explosion; in total, 77 deceased, and 425 injured persons. No disasters or MCIs caused by a natural hazard have been recorded in the past 25 years. These 12 disasters and MCIs occurred in the area of nine hospitals (three in one, two in one, and one in seven hospitals each, respectively), and six hospital districts (six in one, two in one, and one in four hospital districts each, respectively). All the HPPs of the hospitals which had experienced a disaster in their area, and which were analyzed in the study, were updated after the last disaster.

The overall preparedness level in Finnish hospitals was 75.7% with a minimum of 63.4%, and a maximum of 87.3% (Figure 2). The highest overall scores were in command and control (median 92.9%, minimum 71.4%, maximum 100%) and safety and security (90.2%, 68.8%, 100%, respectively). The lowest overall scores were in post-disaster recovery (median 50.0%, minimum 10.0%, maximum 100%) and surge capacity (65.4%, 42.3%, 80.8%, respectively). Preparedness was better in triage (median 80.0%, minimum 65.0%, maximum 95.0%), continuity of essential services (80.0%, 60.0%, 90.0%, respectively), and communication (77.8%, 66.7%, 94.4%, respectively) than it was in human resources (67.5%, 50.0%, 100%, respectively). The widest range among hospitals was seen in post-disaster recovery (90%). With the effective level considered as 70%, the key aspects of command and control, safety and security, triage, and continuity of essential services, as well as communication, were effective in the hospitals.

There was no statistical difference between the surge capacity score of the hospitals which had a disaster or MCI in their area during the past 25 years, compared to those which did not (65.4% for both, $P = 0.735$) (Figure 3).

Due to the wide range in post-disaster recovery scores, the comparison was also analyzed post-hoc for that key component. Again, there was no statistically significant difference of scores between hospitals that had experienced a disaster and those that did not (50% for both groups, $P = 0.772$).

Limitations

This study had several limitations. The HPPs were only analyzed based on the written medical contingency plans without further interviewing the hospital personnel and management. The HPPs were read and analyzed by only one person and thus susceptible to some bias. The study was conducted over 12 months due to COVID-19 pandemic. However, the HPPs were read and analyzed three times to enhance the consistency of the analysis. This study used the previously published WHO tool, and while several study groups have used multiple tools to evaluate the hospital preparedness plans, no single tool has been proven to be

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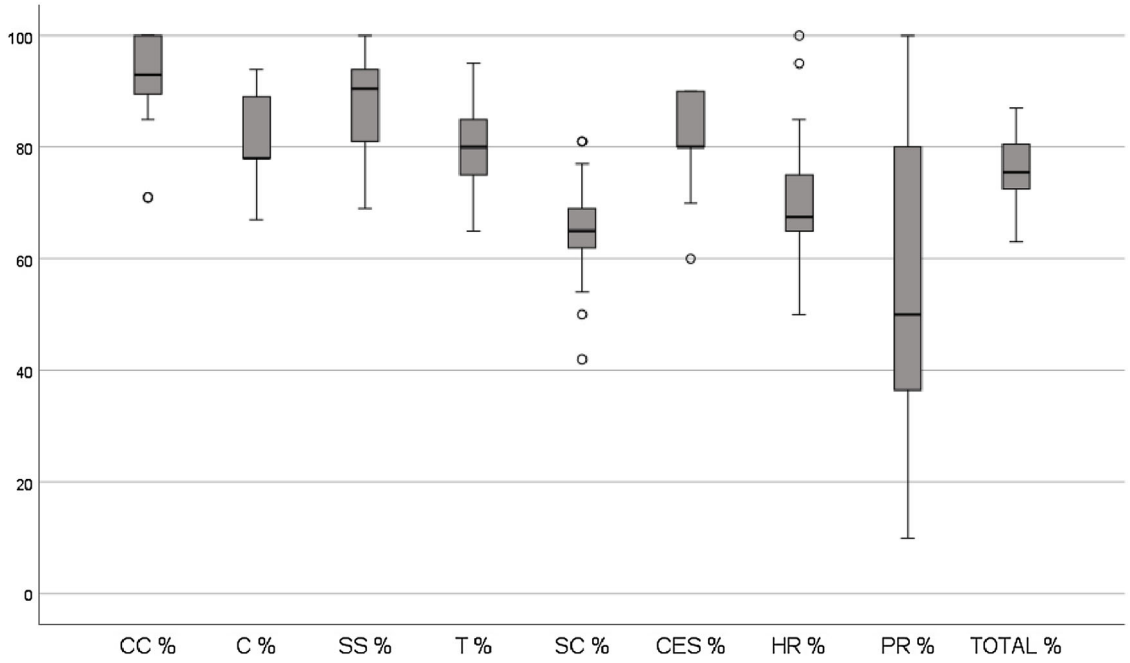

Figure 2. Total score of hospital preparedness plans in Finland. Total score of 28 hospitals' preparedness plans, evaluated with World Health Organization's hospital emergency checklist tool's 8 key components, and represented as a percentage of the highest score possible. Box plots display the median (*bold transverse line*), interquartile range (*rectangle*), range (*whiskers*), and outliers (*dots*). *CC, Command and control; C, Communication; SS, Safety and security; T, Triage; SC, Surge capacity; CES, Continuity of essential services; HR, Human resources; PR, Post-disaster recovery.

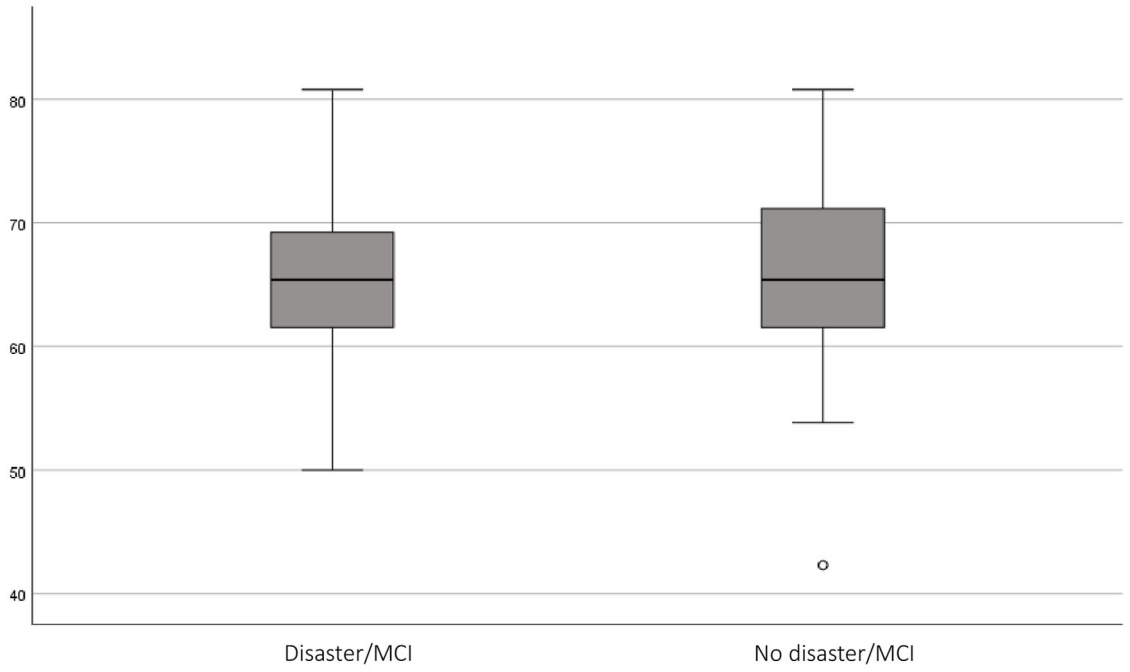

Figure 3. Effect of a disaster on the local hospital's surge capacity preparedness plan. Total score of 28 hospitals' preparedness plans' surge capacity aspect, evaluated with World Health Organization's hospital emergency checklist tool and represented as % of the highest score possible, was compared with Mann-Withey *U* test between hospitals which had, and had not experienced a disaster or mass casualty incident (MCI) in their area during the past 25 years. Box plots display the median (*bold transverse line*), interquartile range (*rectangle*), range (*whiskers*), and outliers (*dots*).

superior.[14,15] For helping the evaluation of this complex aspect and enabling comparison with other plans and countries, a more valid and reliable tool for evaluating hospital preparedness and surge capacity should be developed and validated.[15,16] Some action items were excluded in the study due to the inability to analyze them based only on the written HPPs; thus possibly impairing the reliability of the tool, but for surge capacity, all 13 action items were included. As the study was not randomized, it would be impossible to randomize hospitals to experience a disaster; it is theoretically possible that hospitals experiencing a disaster had a lower baseline

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surge capacity score than others. In addition, while the study was able to show that experiencing a disaster did not appear to alter surge capacity preparedness, it did not explore why. Specifically, the study did not address debriefing techniques, how hospitals revise their plans, or how the hospital attempted to turn the lessons observed into lessons learned.

Discussion

This study found no significant difference in the quality of surge capacity preparedness between hospitals that had previously been exposed to a disaster and those that had not. The median score of surge capacity in the hospitals studied was only 65% on the WHO HPP checklist, and thus classified in the "insufficient" category. This suggests that simply experiencing a disaster does not automatically lead to improvement in surge capacity preparedness as measured by the WHO checklist.

The level and effectiveness of preparedness in Finnish hospitals bear comparison with other countries: in the Netherlands in 2002, 89% of hospitals had a disaster plan, in Switzerland in 2018 the same number was 92%, and in South Africa in 2008, it was 93%.[4,17,18] In 2012, the average hospital preparedness level for disaster management amongst 27 European Union member states was 54% when analyzed using a modified WHO toolkit.[19] In Italy, 3 out of 15 hospitals (20%) and in Yemen, one out of 11 hospitals (9%) had an effective preparedness level with an average overall preparedness level of 56%, and 38% respectively.[5,10]

The less than adequate consideration of surge capacity in HPPs is a worldwide phenomenon.[4–10] In hospitals in Italy and Yemen, the average surge capacity level was 42% and 38% respectively, when analyzed using the WHO checklist.[5,10] In Canada, only 54% of the examined hospitals were aware of their surge capacity, while in South Africa, only 26% were aware.[4,6] In a study of 53 Swedish hospitals, the surgical surge capacity could be increased 3.8-fold in respect of trauma teams, surgical theaters, and intensive care unit (ICU) beds available in 8 hours, but their daily usage levels were not analyzed.[9] In USA, 50 - 86% of the examined hospitals had taken into consideration different parts of the surge capacity, like cancellation of elective procedures, and setting up alternate care areas.[7,8]

There are several reasons why exposure to a disaster may fail to lead to meaningful improvements in surge capacity preparedness. First, it is unclear if all institutions had a structured debriefing process to facilitate the translation of observations into meaningful changes in the disaster plan. This echoes the common theme that lessons observed are not always lessons learned. Second, hospitals who succeed in responding to a disaster may be eager to emphasize the successes in their response, and hesitant to acknowledge the shortcomings. They may feel that no changes are needed to their disaster plans, as they were able to cope with the situation. However, the low overall scores of the surge capacity plans in Finland suggests that improvement is in fact needed. Finally, as disasters are infrequent events, disaster planning may require much more deliberate evaluation and planning to maintain institutional expertise when compared to more normal day-to-day operations.

The overall level of surge capacity preparedness in Finland was insufficient as per the WHO tool: this may be synonymous to the examples of other western countries. Surge capacity is an important marker for overall hospital preparedness, as it is limited not only by the number of beds in the emergency department (ED) and wards, but also by the resources of the ICU, operating rooms, and trauma teams.[1,3,20–22] Surge capacity can be locally enhanced (especially in a disaster situation) by maneuvers such as cancelling elective procedures and admissions, adding extra beds, discharging inpatients, and finding alternative sites for care, particularly for less injured and ill patients.[23,24] In some papers, the realistic surge capacity of a hospital is thought to be 20% more than its usual capacity.[5,10] Mathematical models have been introduced to calculate the surge capacity, but they rely heavily on available beds in the ED, which studies show is not the critical part in surge capacity.[1,20,25,26] The ineffective level of surge capacity in Finnish hospitals might be due to the lack of proper methods for measuring the complex surge capacity or the fact that hospitals tend to overestimate their surge capacity before a disaster or MCI occurs.[3,20,21] In addition, as the demands for patient care continue to grow, many of the resources previously considered as surge capacity reserves are being used on a daily basis, thus reducing the real reserve capacity during a MCI or disaster.[1,3,27] Increased demands in health care, centralization of treatment, closure of smaller local hospitals, and nursing shortage has led to overcrowded EDs and aggravated access to primary and specialty care, leading to many hospitals working at full capacity on a daily basis.[3,8,27–29] Until now, each of the 21 hospital districts in Finland have been authorized to create, rehearse, and implement their own medical contingency plan without uniform standards.[13] The lack of a national strategy for disaster preparedness could be contributory, as it may be unrealistic to rely on individual hospitals alone to cope with a disaster in their area.[3,30] This study suggests that more consideration and improvement should be directed towards surge capacity in the HPPs in Finland.

Several other interesting insights can be collected from the WHO evaluation checklist scores. This study found that in Finland, at least 97% (28/29) hospitals receiving surgical emergency patients had a written HPP. Overall preparedness level was 76% when analyzed using the WHO checklist, thus considered as "effective." Finland is a small country in Northern Europe; part of the European Union with a comprehensive social security system, and public healthcare funded by taxation. After the Winter War and Continuation War (1939 – 1944), Finland developed into a politically non-violent and stable country. In 2020 it was 14th in the Global Peace Index ranking out of 152 countries involved. Currently, Finland is not a geologically disaster-prone country, as seen in the fact that no natural disasters or MCIs have occurred in Finland during the past 25 years. It is also a safe country where only 12 anthropogenic disasters and MCIs occurred during the last 25 years. However, even a moderate number of casualties arriving at the same time to an ED may require special arrangements to be taken into consideration, and thus they can be considered as an MCI: the three incidents labeled as a disaster had 79 – 171 casualties each, thus overwhelming local hospital's resources. Enhancing the impact of these disasters and MCIs, the hospital staff in a non-disaster-prone country might not feel adequately prepared to confront and work in a disaster.[31] The attitude, knowledge, and skills of the hospital staff can be enhanced with training.[20,31] A proper HPP which includes the key aspects is a crucial part of the disaster response.[1,2,32] The wide coverage of HPPs in Finland may also be explained by the fact that it is mandatory by law for hospital districts to have a medical contingency plan.[13] Finland's military history, size of the population, and wide public health care may explain the overall effective level of HPPs throughout the country.

In the HPP, the area with the most coverage in Finland, is command and control (WHO checklist level 93%). This may

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reflect the highly organized Finnish Defense Forces. As in the military, a designated Incident Command System consisting of everyday key management staff with additional units or persons is also a widely accepted key feature in the HPP. The hospital incident command system is preferably a linear, hierarchical organization with specific tasks; this is crucial to manage a chaotic and unpredictable situation of a disaster or MCI.[1,32,33] The least prepared aspect nationally, was the post-disaster recovery plan (WHO checklist level 50%). Despite often being understated in the hospital disaster plan, the recovery phase might last from weeks or months, and with increased patient visits in ED, and physically and emotionally tired workers, it may require additional resources, and thus should not be ignored in a plan.[32,33] The scarce incidence of disasters and MCIs in Finland during the last 25 years might explain the ineffective preparedness in post-disaster recovery.

The primary aim of this study was to determine if surge capacity preparedness differs between hospitals that have previously been exposed to a disaster, and those that have not. This study suggests that exposure to a disaster does not necessarily lead to increased surge capacity when compared to other hospitals in the same country. The results suggest that disaster medicine responders may need to seek a more deliberate or structured approach in turning experience with one disaster into deliberate preparation for the next. In addition, the study suggests that as overall surge capacity preparation in Finland is low, further efforts should be implemented for improvement.

To the best of our knowledge, this is the first study to evaluate hospital disaster preparedness in Finland using an internationally standardized tool. The WHO all-hazard tool Hospital emergency response checklist contains the main key components of a HPP and has been used in previous studies.[2,5,10,16,19] This study is also one of the most comprehensive studies exploring overall national hospital preparedness in a developed non-disaster-prone country with 97% of nation's hospitals included in the study.

Conclusion

In this study, there was no significant difference between hospital surge capacity preparedness in hospitals that had been exposed to a disaster, and those that had not. This indicates that simply experiencing a disaster is not adequate to guarantee that a hospital is more prepared for a disaster. In Finland, the overall hospital preparedness level is effective, with 'command and control' being the best covered area, and 'post-disaster response' the least acknowledged part. The overall level of surge capacity preparedness was 65% using the WHO checklist: "insufficient" by published standards. The study suggests that disaster planning should include structured and meaningful post-action processes to ensure that lessons observed during disaster response are translated into substantial improvements in disaster preparedness.

Supplementary material. To view supplementary material for this article, please visit https://doi.org/10.1017/dmp.2024.1

Availability of data and materials. The datasets analyzed during the current study are available from the corresponding author on reasonable request, with the consideration of the confidentiality principle specified in the article.

Authors' contributions. AK, JMF, and EH designed the study concept. AK and EH collected the data (medical contingency plans), and AK carried out the analysis and interpretation of the data, as well as statistical analysis with the guidance of JMF. AK also did the drafting of the manuscript, while JMF and EH revised the manuscript before submission. All authors read and approved the final manuscript.

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Competing interests. JMF is the CEO and founder of STAT59 (Stat59, Edmonton, Alberta, Canada). The remaining authors declare that they have no competing interests.

Ethics approval and consent to participate. Not applicable (not involving the use of any animal or human data or tissue, but the data for analysis was given with the permission of each hospital district's medical directors knowing the purpose of this study). This study was approved by the Institutional Review Board (IRB) of the Hospital District of Helsinki and Uusimaa (protocol number HUS/917/2021).

Consent for publication. Not applicable (not containing data from any individual person).

Authors' information. This work is the result of a thesis submitted in partial fulfilment of the requirements for the degree of Master of Science in Disaster Medicine (European Master in Disaster Medicine).

Abbreviations. ED, Emergency Department; HPP, Hospital Preparedness Plan; ICU, Intensive Care Unit; IRB, Institutional Review Board; MCI, Mass Casualty Incident; WHO, World Health Organization

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